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(71) Applicant: GENERAL MOTORS CORPORATION
General Motors Building 3044 West Grand Boulevard
Detroit Michigan 48202(US)

(72) Inventor: Turner, Kenneth William
433 Tara Lane
Webster, NY 14580(US)

Inventor: Alfred, Peter John
320 Victor Egypt Road
NY 14564(US)

Inventor: Smith Du Bois, Patti
2406 Church Road
Hamlin, NY 14464(US)

Inventor: Greer, Thomas Wayne
195 Durnan Street
Rochester, NY 14621(US)

(74) Representative: Haines, Arthur Donald et al
Patent Section 1st Floor Gideon House 28 Chapel Street
Luton, Bedfordshire LU1 2SE(GB)

(54) Separator for separating water from a flow of air.

(57) The intake for a fuel vapour storage canister (12) separates entrained water from the entering purge flow. A separator (10) in the form of an open-ended box includes a series of alternating, interleaved, and downwardly sloped fins (28,30,32), the free edges of which create a series of restricting gaps (X_1 - X_4) that decrease in size in the upstream direction. Each gap, for some defined subrange of the total possible range of flow rates, accelerates the flow into the fin (28,30,32) above it at the optimal velocity for water stripping.

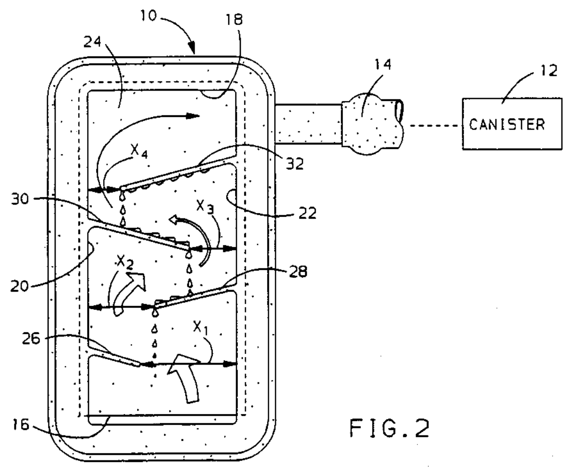

FIG.2

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This invention relates to a separator adapted to remove entrained water from a flow of air drawn from surrounding atmosphere and used to purge adsorbed fuel vapour from a storage canister.

Vehicle fuel systems have long used activated carbon filled canisters to hold temporarily fuel vapours that would have been simply vented in years past. The stored vapours are desorbed from the carbon when the engine runs by using a manifold vacuum to draw fresh air from the surrounding atmosphere through the canister, and ultimately to the engine for burning. This process is generally referred to as purging, and the air drawn in referred to as purge air.

In order to achieve maximum purge efficiency, purge air cannot be drawn in at a constant flow rate. Instead, various computer controls and valves are used to draw purge air at the maximum rate that can be handled by the engine under the determined conditions. While there is a known maximum-to-minimum total range of purge flow rates, the actual rate will vary continually.

Another factor that can potentially affect efficiency is that the purge flow may in fact be more than just air, and may include a significant percentage of entrained water in the form of a fine mist or droplets. While this is apparently not a well recognized problem, it is known that water in the carbon canister can adversely affect its fuel vapour adsorption capacity. In the future, even larger carbon canisters may have to be carried in vehicle locations where they will be subjected to higher water percentages in the purge air flow.

The general problem of entrained water separation is recognized in the gas purification field. Louver type separators are known that pass the flow across an array of slats in such a way that it impinges upon the surface of the slats. The entrained water is stripped from the flow, collecting on the surface of the slats. It has been found that there is an optimal flow velocity, in the range of 2.13 to 3.05 metres per second (7-10 feet per second), at which the stripped and collected water will not be picked up again by the passing flow. Therefore, it is a relatively simple matter to design the equipment so that the flow is drawn in at the optimal velocity. However, as noted above, this is not feasible in vehicle evaporative control systems, where the flow rate varies.

The present invention seeks to provide an improved separator.

According to an aspect of the present invention, there is provided a separator for removing entrained water from a flow of air as specified in claim 1.

The provision of restricting gaps of different sizes enables substantially optimum flow velocity to be reached, so as to provide substantially the optimum separation of water over a variety of air flow rates.

In a preferred embodiment the restricting gaps decrease in size in the direction of the air flow, and the separator is arranged so that separated water droplets move back towards and out of the inlet of the separator. With this arrangement of restricting gaps, the separated water droplets will see a gradually reducing air flow velocity, and there will thus be substantially no possibility of the water droplets being re-entrained into the air flow.

In another embodiment, the restricting gaps increase in size in the direction of the air flow. For example, as will be apparent to the skilled person, the separator could be designed such that separated water droplets are made to move in the direction of the air flow and then removed from the separator by any suitable means.

The invention can provide a separator for removing entrained water from a purge air flow that is effective over a variety of inflow velocities.

In the embodiment described below, the separator includes an inflow chamber in the form of an open ended box that is fixed to the vehicle body with the open end at the bottom. A purge tube opens through the upper end of the box, and purge vacuum is applied thereto to draw a purge flow from ambient through the lower end. A series of four downwardly sloped fins is integrally moulded inside the box, each with a free edge that terminates deliberately short of an opposed side wall, thereby creating a restricting gap. The fins are interleaved and alternated, so that the next fin in the series is above a gap. The fins are successively longer, so that the gaps they create decrease from bottom to top. Each gap is chosen so that its area will, for some subrange of entering flow rate, accelerate the flow to approximately the optimal velocity for water separation.

In operation, when purge is commenced, a flow from ambient is drawn in from ambient at whatever flow rate the purge program calls for. The purge flow enters the open box end, and then travels up and around the fins in series in a tortuous, serpentine path, passing through each successive gap before reaching the purge line at the top. The underside of each fin is exposed to the airflow that slips past the edge of the fin beneath, which impinges forcefully thereon. The entering flow is accelerated as it passes through each successively smaller gap. At some point, because of the way in which the gaps are deliberately sized, the flow velocity will approach the optimal separation velocity, the entrained water droplets will collect on the underside of the fin just above. As a result of the downward fin slope, collected water can drain down, opposite to the purge flow direction. Since it faces an ever slower flow, the draining water will not be re-entrained, and can simply fall out the bottom.

With the invention, it is therefore possible to remove entrained water from the purge flow into a vehicle fuel vapour canister. It can also provide a separator that is not dependent on providing a single, constant rate of inflow to the separator.

The invention can also provide a separator that uses a series of fins on which the flow successively impinges, and a series of successively decreasing gaps through which the flow must pass, thereby successively accelerating the flow so that the flow impinging on some fin can be expected to approximate the optimal velocity for water separation. It can also provide a separator in which the fins are arranged to allow the entrained water to drain down without being picked up again by the downstream flow.

According to another aspect of the present invention, there is provided a vehicle comprising a fuel vapour canister and a separator as herein specified, the separator being adapted to provide purge air to the fuel vapour canister.

An embodiment of the present invention is described below, by way of illustration only, with reference to the accompanying drawing, in which:

Figure 1 is a perspective view of an embodiment of separator with part of the case thereof shown broken away; and

Figure 2 is a side view of an open side of the case showing the flow direction.

Referring to the drawing, a preferred embodiment of separator 10 is adapted for use in conjunction with a vehicle fuel evaporation control system, the main component of which is an activated carbon canister 12. Canister 12 stores excess fuel vapours by adsorption, which are later purged when manifold vacuum draws fresh air in from the surrounding atmosphere, through a purge line 14. The purge flow rate is deliberately varied by the vehicle's control system, so that as much vapour can be purged as the engine can handle at any point in time. A constant purge flow rate would be simpler to create, but not nearly so efficient. While the purge flow rate provided through purge line 14 varies, the total range over which it varies from maximum to minimum can be predicted fairly closely. Separator 10 is designed on the basis of that known total range of purge flow rates.

Separator 10 is basically a rectangular, hollow box, moulded of a suitably hard plastics material such as nylon. Although it is moulded with an open side for ease of manufacture, as shown, that side of the box would be closed when mounted to the vehicle. Separator 10 is then totally sealed except for the open inlet 16 at one end and the opposite end surface 18, which receives the purge line 14. Separator 10 is mounted vertically, with inlet 16 at the bottom and end surface 18 at the top. Therefore, when a vacuum is applied through purge line 14, a purge flow of air and whatever is mixed with the air is drawn through inlet 16 to purge line 14. The upstream direction of flow depends on the orientation of separator 10, and in the embodiment shown in the Figures is upward, counter to gravity. Inlet 16 is large enough so as not to restrict substantially the flow of ambient air that the vehicle's vacuum is able to draw in, and the pressure differential between purge line 14 and inlet 16 will not be great enough to cause any significant expansion or contraction of the air drawn in. So, the predicted total range of flow rates through purge line 14 will be seen at inlet 16, as well. Separator 10 includes an interior structure that works on the purge flow to remove any water entrained therein, described next.

Being a basic box, separator 10 has three side walls, 20, 22 and 24, all of which would be substantially vertical when separator 10 is mounted as shown. Moulded integrally to the interior is a series of four fins 26 to 32 which are interleaved and alternating. That is, two fins 26 and 30 are moulded to side wall 20 and the centre side wall 24, and the other two fins 28 and 32, are moulded to the centre side wall 24 and the side wall 22 opposite to side wall 20. Fins 26-32 are substantially evenly spaced from one another in the vertical direction, and each is also sloped slightly downwardly, towards the opening 16, about fifteen degrees from the horizontal. However, each fin is deliberately of different length, shorter than the fin above it. Thus, the free edge of each fin 26-32 is spaced from its opposite side wall 20 or 22 by an increasingly smaller amount, creating four different restricting gaps of successively decreasing size, numbered X_1, through X_4. As a result of their alternating, interleaved relation, the underside of every fin except the first fin 26 faces the gap created by the fin below it, while first fin 26 directly faces inlet 16. When the separator 10 is mounted and its open side is closed, there is no flow path available from inlet 16 to purge line 14 other than around the free edges of the fins.

Referring to Figure 2, the operation of separator 10 is illustrated. When a vacuum is applied at purge line 14, a purge flow is created that enters inlet 16, moving up and through each gap in a forced serpentine pattern. Since each successive gap is smaller, the purge flow will be restricted in area and its speed will be accelerated and increased as it slips past the free edge of each successive fin. This effect is visually represented by the narrowing and lengthening arrows. The flow through each gap will also be forced to impinge upon the underside of the fin just above it. If the flow velocity is within the optimal water stripping velocity range at that point, the entrained water droplets will collect on the underside of the fin upon which it impinges. Below that speed, the water is not stripped out, and above that speed, the water is picked up by the flow and re-entrained. The size of the gaps X_1-X_4 is chosen to assure that substantially the optimal velocity is achieved through at least one gap, for any possible flow rate. The method of sizing the fins is described further below.

In the example illustrated in Figure 2, the optimal stripping speed has been achieved as the flow slipped past the free edge of fin 30, through gap X_3, so it is the uppermost fin 32 that provides the collection surface. As a result of the downward slope of fin 32, and of all the fins below it, the collected water droplets can drain down, landing on the upper side of each successive sloped fin 30-26, and ultimately out of the bottom inlet 16, as illustrated. Since in this embodiment the gaps successively increase in the downstream direction, the flow velocity that the draining water sees will be continually decreasing, and the water will not be blown back upstream and re-entrained. In addition, any dust mixed in the purge flow will collect on the fins as well, and be washed off with the draining water.

To achieve the operation described above, the sizes of the various gaps X_1-X_4 are chosen on the basis of the predetermined total range of possible purge flow rates. The flow rate, in terms of volume per unit of time, would be substantially the same at all points in the flow path, since there is no significant expansion or contraction of the air. The velocity of flow at any point in the flow path, in terms of length per unit of time, will differ with the area of the flow path at that point. Therefore, the velocity or speed with which the flow passing through any gap impinges upon the fin above depends on the area of that gap. Knowing the total possible range of flow rates for the particular system, from minimum to maximum, and knowing that the optimal velocity for stripping water from the purge flow is about 2.13 to 3.05 metres per second (7-10 feet per second), the designer chooses the area of each gap X_1-X_4 such that the optimal flow velocity range will be achieved over some calculated subrange of flow rates. For example, if the maximum expected flow rate is 70 litres per minute, it can be calculated that an area of 3.8 cm^2 will yield a flow velocity of 3.05 metres per second (10 feet per second). That area, in turn, will yield a speed of 2.13 metres per second (7 feet per second) when the flow rate is about 48 litres per minute. Therefore, if the largest gap X_1 is set at 3.8 cm^2 then it will create the optimal stripping velocity over a flow rate subrange of 70 to 48 litres per minute. The same process, starting with an upper limit of 48, is used to calculate X_2 and its particular flow rate subrange, and so on, until the subranges together add up to the total expected range of flow rates. The number of gaps necessary will vary with the breadth of the expected total range. In the particular embodiment disclosed, it will be noted that there is no fin directly above the last gap X_4. However, the flow at that point will impinge directly on the upper end surface 18, which will in effect act like another fin and provide a collection surface. Another option would be to have the inlet 16 of a size adapted to serve as one of the gaps that creates the optimal flow speed. However, the lower fin 26 is short enough that its underside would not likely provide as efficient a collection surface as upper end surface 18.

Variations in the preferred embodiment could be made. The interior of the separator could be provided with a series of flow accelerating gaps that were structurally unrelated to the collection surfaces above them. That would be a more complex and less compact structure than the embodiment disclosed, where the free edge of each fin also cooperates to create the flow accelerating gap for the fin above. The vertical orientation of the separator and downward slope of the fins cooperate to create the self draining action described. Neither might be necessary if the amount of water anticipated was not great. Or, a horizontally oriented separator could be provided with small drain holes separate from the main inlet. This would mean that some flow would be drawn in from the surrounding atmosphere other than just through the inlet, and when provided, the successively decreasing flow velocity through the series of gaps would still assure that collected water would not be re-entrained.

Claims

1. A separator for removing entrained water from a flow of air drawn from the surrounding atmosphere, comprising a chamber (10) including an inlet (16) into which air is drawn from the surrounding atmosphere and an outlet (14); a plurality of restricting gaps (X_1 - X_4) of different sizes within the chamber and adapted to vary the velocity of the flow of air through the chamber so as to provide substantially the optimum velocity for separating entrained water over a plurality of air flow rates; and a plurality of collection surfaces (28,30,32,18) disposed within the chamber, each substantially upsteam of a respective restricting gap relative to the direction of flow of air through the chamber and adapted to cause the air accelerated through the gaps to impinge on one or more of the surfaces and to separate

the water from the flow of air.

2. A separator according to claim 1, wherein the restricting gaps (X_1 - X_4) decrease in size successively in the direction of flow of air through the chamber, the separator being disposed in use such that water droplets separated from the flow of air move towards the inlet (16), thereby facing a decreasing air flow velocity towards the inlet so as substantially to prevent the water droplets being re-entrained into the flow of air.

3. A separator according to claim 1 or 2, wherein the collection surfaces (28,30,32,18) of the separator (10) are provided on respective separator fins (28,30,32,18) each of which fins comprises a free edge past which air flows in use before reaching the collection surface of the next fin in the direction of the air flow, the free edges forming the restricting gaps (X_1 - X_4) within the chamber.

4. A separator according to claim 3, wherein each separator fin (28,30,32,18) slopes towards the inlet (16), whereby in use water droplets separated from the air flow move over the separator fins towards and out of the inlet.

5. A vehicle comprising a fuel vapour canister (12) and a separator (10) according to any preceding claim, the separator being adapted to provide purge air to the fuel vapour canister.

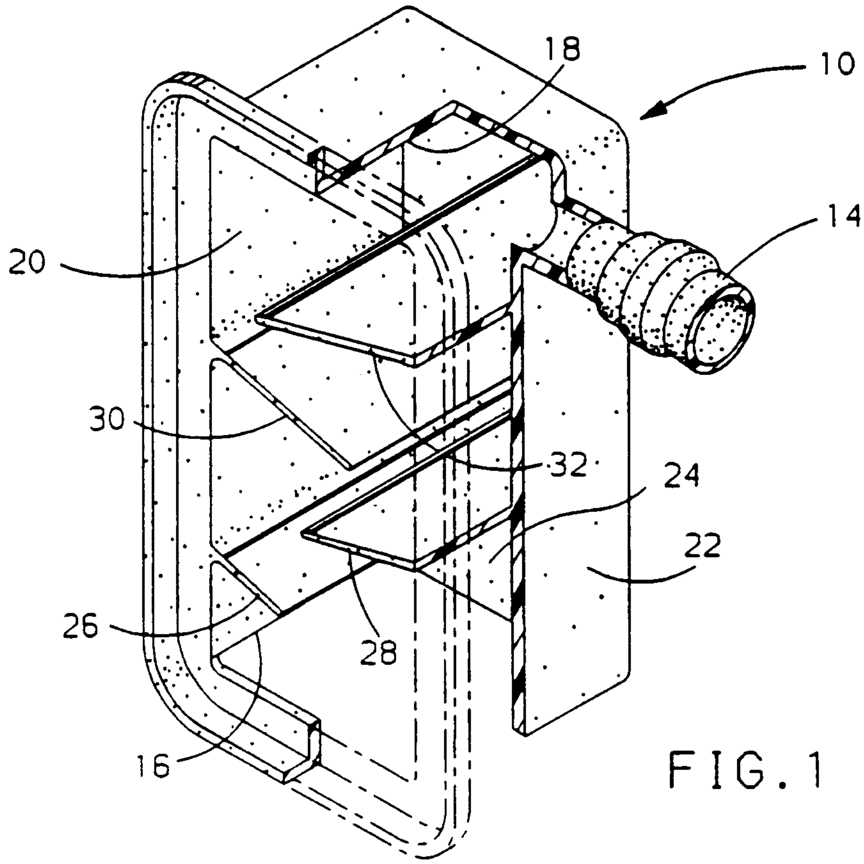
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FIG.1

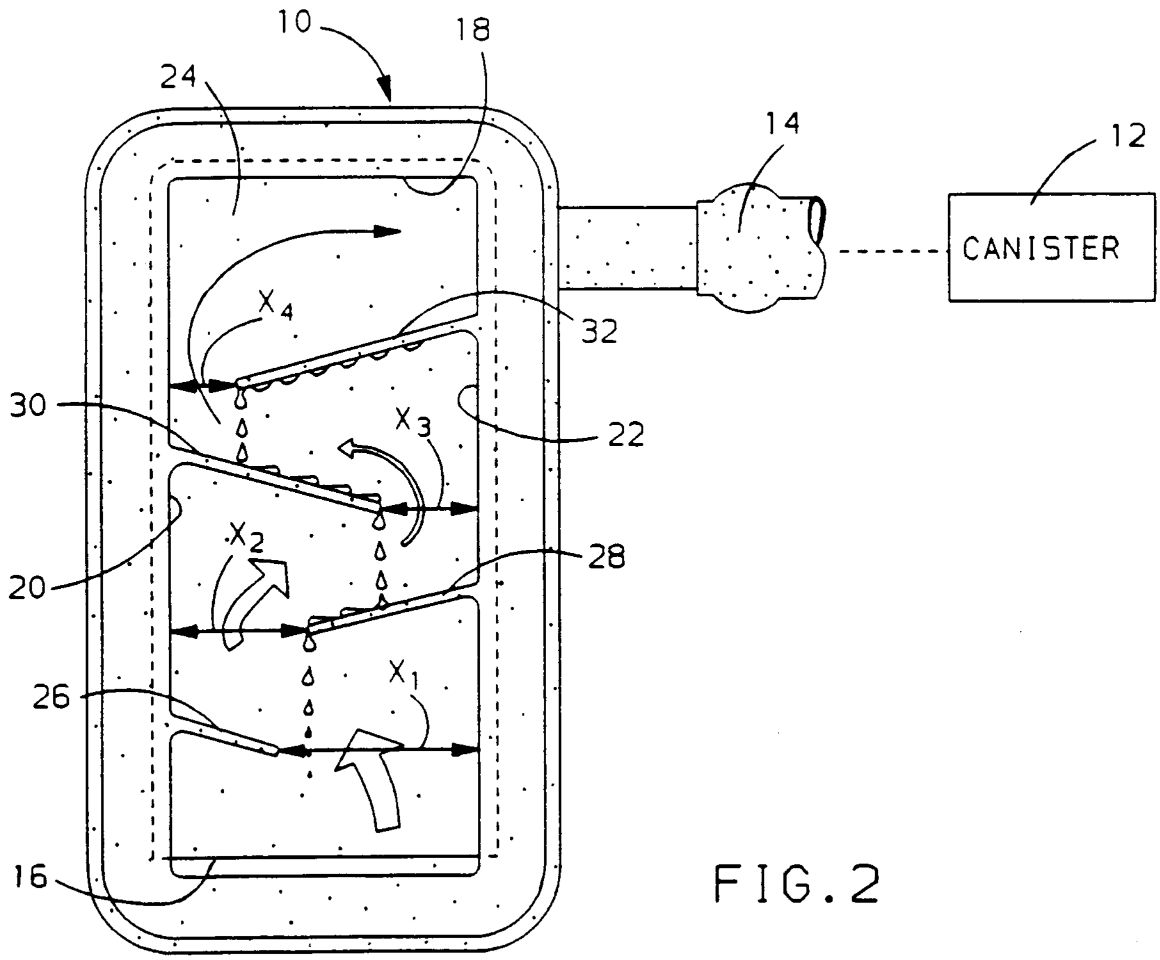
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FIG.2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number: EP 92200278.7

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US - A - 4 175 937 (BRANDAU et al.) * Totality * --	1,2	B 01 D 45/08 B 01 D 45/06 B 60 K 15/035
A	EP - A - 0 272 765 (BURGESS MANNING LIMITED) * Abstract; fig. 2 * --	1	
A	CH - A - 561 076 (MITSUI SHIPBUILDING) * Claim; fig. 2,3,4 * --	1	
A	EP - A - 0 135 488 (COCKERILL MECHANICAL) * Abstract; fig. 2 * ----	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

B 01 D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	22-05-1992	WILFLINGER

CATEGORY OF CITED DOCUMENTS

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